# Thermal Hyperspectral Remote Sensing for Plant Species and Stress Detection

## Details

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| **Meeting** | 2014 Fall Meeting |
| **Section** | Biogeosciences |
| **Session** | Remote Sensing of Vegetation Function and Traits II |
| **Identifier** | B41N-08 |
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| **Index Terms** | Carbon cycling [0428]<br>Remote sensing [0480]<br>Evapotranspiration [1818]<br>Remote sensing [1855] |

## Abstract

Thermal infrared (TIR) spectroscopy offers a novel opportunity for measuring emissivity spectra of natural surfaces. Emissivity spectra are not directly measured, they first have to be retrieved from the raw measurements. Once retrieved, the spectra can be used, for example, to discriminate plant species or to detect plant stress. Knowledge of plant species distribution is essential for the sustainable management of ecosystems. Remote sensing of plant species has so far mostly been limited to data in the visible and near-infrared where, however, different species often reveal similar reflectance curves. Da Luz and Crowley showed in a recent paper that in the TIR plants indeed have distinct spectral features. Also with a certain species, subtle changes of emissivity in certain wavebands may occur, when biochemical compounds change due to osmotic adjustment induced by water stress. Here we show, that i) emissive imaging spectroscopy allows for reliable and accurate retrieval of plant emissivity spectra, ii) emissivity spectra are well suited to discriminate plant species, iii) a reduction in stomatal conductance (caused by stress) changes the thermal infrared signal. For 13 plant species in the laboratory and for 8 plant species in a field setup emissivity spectra were retrieved. A comparison shows, that for most species the shapes of the emissivity curves agree quite well, but that clear offsets between the two types of spectra exist.

Discrimination analysis revealed that based on the lab spectra, 13 species could be distinguished with an average overall classification accuracy of 92% using the 6 best spectral bands. For the field spectra (8 species), a similar high OAA of 89% was achieved. Species discrimination is likely to be possible due to variations in the composition of the superficial epidermal layer of plant leaves and in internal chemical concentrations producing unique emissivity features. However, to date, which spectral feature is responsible for which chemical compound remains unclear. This new technique of TIR spectroscopy bears great potential for floristic mapping and vegetation stress monitoring, besides other applications. Future airborne and spaceborne studies, however, will have to overcome a number of challenges, for instance the cavity effect, atmospheric influences, and signal-to-noise.

**Cite as:** Author(s) (2014), Title, Abstract B41N-08 presented at 2014 Fall Meeting, AGU, San Francisco, Calif., 15-19 Dec.